



FEDspresso – CAFDE Based HLA Federation Development and Implementation Tool Suite

Final Report

22 September 2000

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SBIR OSD97-001 Phase II
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Prepared for:

U.S. Army Simulation, Training and Instrumentation Command
(STRICOM)

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Section 1

1 Forward

1.1 Introduction

The *FEDspresso – CAFDE Based HLA Federation Development and Implementation Tool Suite* Small Business Innovative Research (SBIR) contract is the continuation of a Phase I effort titled *HLA Federation Implementation Tools* under OSD Topic Number OSD97-001. During the Phase I effort, *Synetics* established an architecture for a CASE-like tool environment under which HLA Federations could be rapidly planned, designed, developed, certified, and checked prior to execution. This architecture, referred to as the Computer-Aided Federation Development Environment (CAFDE), embraces and extends the Object Model Tool Development strategy based on the HLA FEDEP model, and provides a well-coordinated approach from which plug-and-play tools may be developed and easily integrated.

Synetics identified functional tool capabilities for the next evolution of federation development tools, mechanisms for on-line collaboration, Application Program Interface (API) calls and Data Interchange Formats (DIFs) for automated data exchange, and support for reusable simulation components such as Reference FOMs, and Base Object Models (BOMs). In addition, *Synetics* developed *FEDspresso™*, a prototype implementation of the CAFDE architecture. The *Synetics FEDspresso™* prototype provided a solid foundation for the Phase II full-scale CAFDE-based tool suite titled OMSuite™.



Synetics was awarded the Phase II effort titled, *FEDspresso – CAFDE Based HLA Federation Development and Implementation Tool Suite*.

The award was under U.S. Army Simulation, Training and Instrumentation Command (STRICOM) contract number M67004-98-C-0032 issued 22 June 1998. During the initial months of development, the *Synetics*' Development Team established the final name of the *Synetics*' object model tool suite as OMSuite™. Therefore, the majority of references to the tool suite in this report will be referred to as OMSuite™ instead of FEDspresso. References to FEDspresso™ are obsolete and are used only for the tools developed during the Phase I effort. The FEDspresso™ Manager, developed in Phase I, is now referred to as OMManager™ and the FEDspresso™ Network Interfaces as OMNet™.

1.2 Summary

The overall objective of the *FEDspresso – CAFDE Based HLA Federation Development and Implementation Tool Suite* SBIR was to develop a suite of tools that would assist federation engineers in the development and implementation of HLA object models in keeping with the Federation Development Execution Process (FEDEP) as defined by the Defense Modeling and Simulation Organization (DMSO). *Synetics* proposed to:

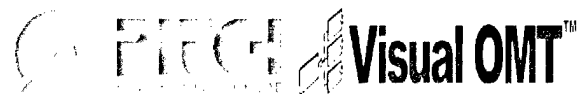
1. Complete the CAFDE open specification, which would allow for the

integration of *Synetics* and third party tools within any CAFDE enabled, integrated federation development environment.

2. Complete the CAFDE Toolbox (CAFDE TBX), which provides a tool developer with CAFDE tools, specifications, and source code, samples for outfitting and testing their tools for CAFDE integration.
3. Develop a CAFDE integrated object model tool suite, OMSuite™, which provides requirements capturing, object model development, lexicon support, collaboration, and execution processing and monitoring in a fully CAFDE enabled environment.
4. Produce the OMSuite™ tools for commercial sale.
5. Establish DoD and commercial Phase III partnerships to provide federation engineering development support using the OMSuite™ tools to plan, design, develop, and execute DoD and commercial federations.

Synetics successfully completed each of its proposed technical objectives. The *Synetics* SBIR development team was aware from the beginning of the SBIR project that it would not be a prudent use of SBIR funding and time to develop tools to assist in every aspect of federation development. Such an effort would have ensured that nothing profitable would have been accomplished. Therefore, *Synetics* developed tools providing federation-engineering support in selected major areas and left areas such as scenario development to those with greater experience. The CAFDE architecture will provide the integration methods to allow other tools, from other vendors, to integrate with OMSuite™ to provide a more robust environment from which to work. This integration process was proven during the SBIR when IBIS Research (Vancouver, BC)

and Pitch AB (Sweden) implemented the CAFDE architecture into their respective products. Their success and the ease of implementation were published in the SIW paper *Lessons Learned and Benefits of CAFDE Tool Integration*¹ and presented to the community during the fall 1999 SIW.



1.3 Conclusions

The research and development efforts of the *Synetics* OMSuite™ development team demonstrate that a federation development and implementation tool suite is possible. *Synetics* OMSuite™ provides the DoD and commercial federation engineering teams with tools to support their respective federation engineering development tasks in an integrated environment. *Synetics* provides successful integration and collaboration of data within the OMSuite™ tool environment and shows the commercial worth of OMSuite™ by having successfully sold the tools to non-DoD customers and foreign governments. Additionally, OMCase™, as product of OMSuite™, is currently being applied in areas of software development for requirements capturing and object model development. This has expanded the original charter for the tool suite making it a viable candidate for major software engineering support and configuration management.

¹ Jane Bachman., Reggie Chen, Björn Löfstrand, Mark McAuliffe, "Lessons Learned and Benefits of CAFDE Tool Integration" 1999 Fall Simulation Interoperability Workshop Papers, Volume I (99F-SIW-074), September 1999.

Section 2

2 SBIR Detailed Results

Section 2 of this report provides a complete and detailed description of the SBIR effort with analytic results and conclusions dealing with the development of HLA Federation Implementation Tools. This section is divided into four subsections dealing with *Synetics* goals and innovative technologies, community impact and involvement, resulting SBIR products, and resulting SBIR commercialization.

2.1 Goals & Innovative Technologies

The development of a High Level Architecture (HLA) federation typically requires extensive collaboration among federation participants and sponsors in the areas of requirements definition, object model and scenario development, and subsequent federation execution. Given the complexity and potential for errors in the manual processes used in the early days of HLA federation development, it was determined by the HLA Modeling and Simulation community that HLA federation tools were needed. *Synetics* took on the challenge to develop a set of tools that would provide the greatest coverage across the HLA federation engineering process. However, the *Synetics* engineers determined early in the tool development process that it would not be a prudent use of SBIR funds to develop tools that encompassed the entire federation engineering process, though. *Synetics* engineers had differing talents within modeling and simulation but knew that they did not have expertise in all areas.

An example of an area that *Synetics* would not tackle was the area of scenario generation. This was an area where *Synetics*

lacked the talents to produce a tool that would meet the rigorous demands of a federation engineer in developing a scenario. However, *Synetics* engineers have over 50 years of combined software engineering and modeling and simulation experience. This experience was put to use during the SBIR to develop tools that would meet the high level federation engineering demands for requirements capturing, object model development, and execution monitoring.

As will be described in subsequent paragraphs, the overall goal of the *FEDspresso – CAFDE Based HLA Federation Development and Implementation Tool Suite* SBIR was to develop a suite of tools that would assist federation engineers in the development and implementation of HLA object models in keeping with the Federation Development Execution Process (FEDEP) as defined by the Defense Modeling and Simulation Organization (DMSO). The goals included:

1. Complete the CAFDE open specification, which would allow for the integration of *Synetics* and third party tools within any CAFDE enabled, integrated federation development environment.
2. Complete the CAFDE Toolbox (CAFDE TBX), which provides a tool developer with CAFDE tools, specifications, and source code, samples for outfitting and testing their tools for CAFDE integration.
3. Develop a CAFDE integrated object model tool suite, OMSuite™, which provides requirements capturing, object model development, lexicon support, collaboration, and execution processing

and monitoring in a fully CAFDE enabled environment.

4. Produce the OMSuite™ tools for commercial sale.
5. Establish DoD and commercial Phase III partnerships to provide federation engineering development support using the OMSuite™ tools to plan, design, develop, and execute DoD and commercial federations.

2.1.1 Open CAFDE Specification



One of *Synetics* innovative contributions to the HLA and software engineering communities is the CAFDE Architecture. From the onset of the Phase II program, *Synetics* sought to provide the HLA federation engineering community with an open tool architecture that would provide a way for users to select the tools of

their choice, regardless of the tool vendor, and conform them within a single integrated environment. The Computer Aided Federation Development Environment (CAFDE) provides this architecture. Specifically, CAFDE provides an open framework for the integration, data sharing and collaboration among a wide variety of applications and tool environments (see Figure 1). Although CAFDE was intended to support the development of next generation, plug-and-play High Level Architecture (HLA) development tools for the modeling and simulation (M&S) community, it has grown to provide enough flexibility to support a myriad of purposes and software applications. Therefore, although much discussion has been made over the last two years towards HLA development, the Application Program Interface (API) routines within CAFDE are useful for the integration of other tools and applications.

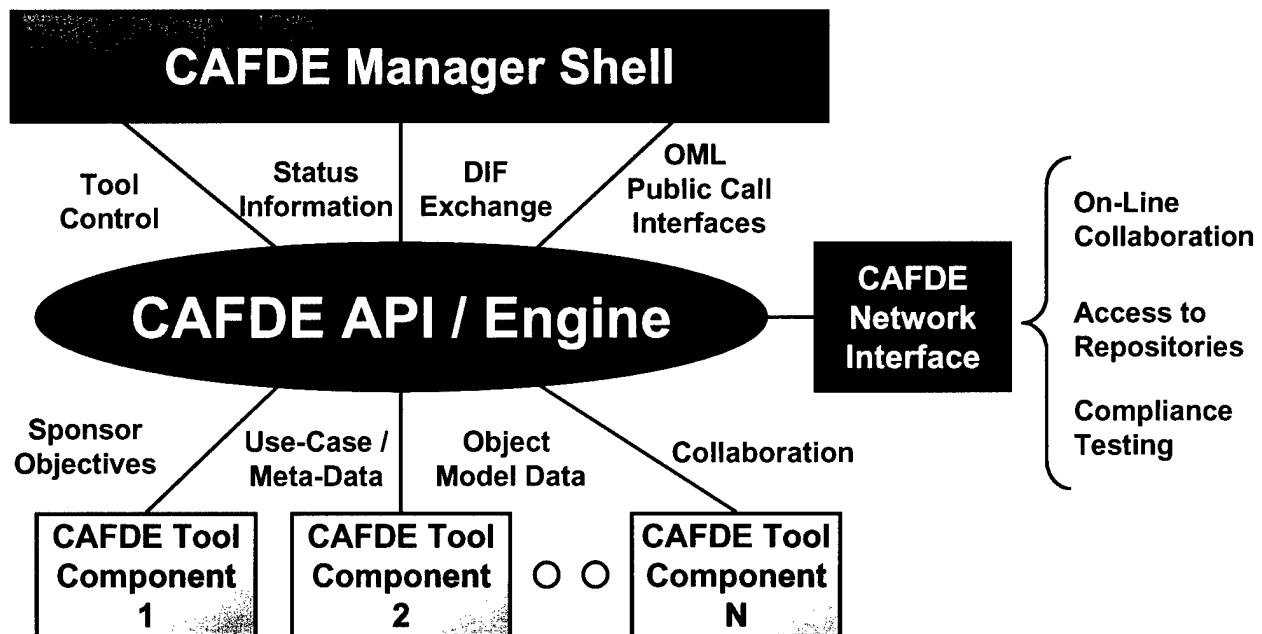


Figure 1 – CAFDE Architecture

In regards to HLA, CAFDE provides a common tool framework for rapid federation development through the full federation-engineering life cycle. The CAFDE Architecture encompasses HLA Data Interchange Formats (DIFs), tool environment elements, and a set of CAFDE-specific Application Program Interface (API) routines designed to allow tool developers to take advantage of tool integration and automation capabilities.

The CAFDE Specification is intended to provide a single API to which application developers can program and multiple tool vendors can conform. In the context of a particular operating system, it defines a binary interface such that an application written to the CAFDE API can work with a conformant CAFDE implementation (called the CAFDE Engine) from any tool vendor. In addition, the specification defines the capability requirements of a CAFDE Manager component necessary to support desktop management and integration of multiple applications and a CAFDE Network Interface necessary to support on-line collaboration over a network. The specification defines the library calls and associated semantics to which an application developer and tool vendor can program CAFDE applications and binary interfaces.

The CAFDE architecture provides a set of CAFDE-specific Application Program Interface (API) routines designed to support automated, multi-tool integrated development resulting in an open interface for a wide variety of tools and applications that need to share and exchange information. The CAFDE API provides a way to “wire tools” together and collaborate with other user tool environments. As a result, the CAFDE architecture promotes the following characteristics and capabilities:

1. Seamless Integrated Development Environment (IDE)
2. Language Independence (support exists for C, C++, Delphi, Java, LISP, etc...)
3. Cross-Tool Communication and Automation (via API/DIFs) within a Single Environment
4. Collaboration and Data Exchange among Multiple Environments
5. Subscription Oriented Data Delivery
6. Data Querying within in a Single Environment and Multiple Environments
7. Abstract Network Interface (supporting protocol independence)

These characteristics allow the following types of tools and features to be supported within CAFDE’s *integrated* and *collaborative* tool environment.

1. CASE-like tools including support for Unified Modeling Language (UML)
2. Automated Requirements Collection / Checking Tools
3. Construction / Reuse of data components such as SOMs and FOMs (Including BOMs)
4. Code / Scenario Generation Tools
5. Scriptable Wizards (e.g. FEDEP Wizard)
6. Access to On-Line Repositories
7. Support for, Microsoft DirectPlay, SOAP, TCP/IP, HLA RTI and other communication protocols

The CAFDE architecture is the framework behind the OMSuite™ tools developed by **Synetics** in support of HLA federation development.

2.1.2 FEDEP-based Integrated Development Environment

A primary goal for **Synetics** during the SBIR Phase II effort was to use the CAFDE architecture, to fully embrace the Federation Development and Execution Process

(FEDEP) within the tools we were creating. Figure 2 and Table 1 illustrate and describe the integration and automation support of CAFDE to the FEDEP. Figure 3 illustrates

how OMSuite™ assists the federation engineering in developing and monitoring a federation.

Table 1 - CAFDE Automation Support

FEDEP ELEMENTS:	Step One	Step Two	Step Three	Step Four	Step Five	Step Six
Sponsor Needs	YES	YES				
Objectives Development	YES					
Scenario Development		YES				
Conceptual Analysis						
Select Federates			YES			
Allocate Functionality			YES			
Prepare Development Plan			YES			
Develop FOM				YES		
Establish Federation Agreements				YES		
Implement Federate Modifications				YES		
Execution Planning					YES	
Federation Integration & Test					YES	
Federation Execution					YES	
Results						YES
Feedback						YES

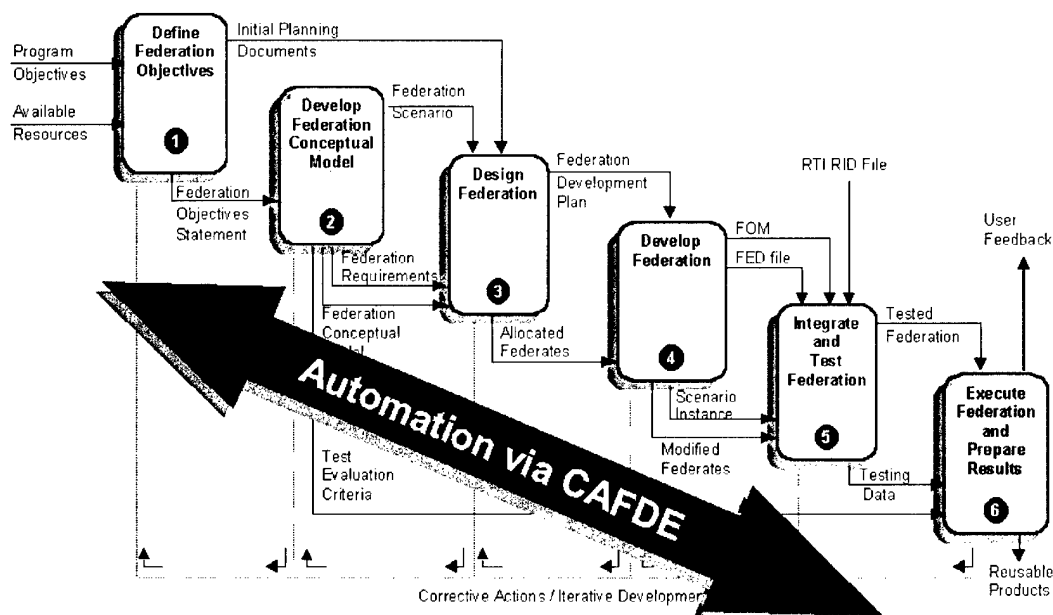


Figure 2 - HLA Federation Development and Execution Process (FEDEP)

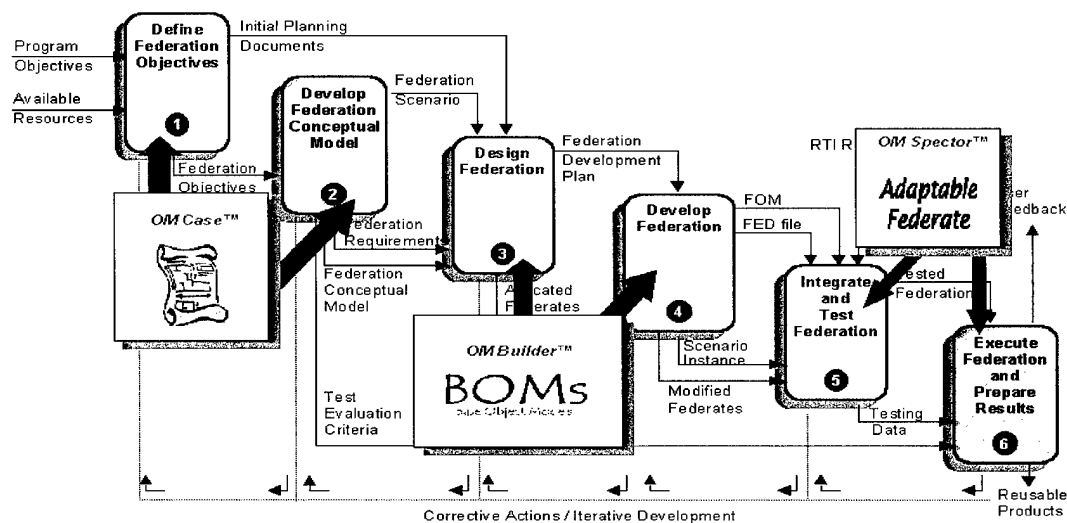


Figure 3 - HLA FEDEP and the OMSuite™ Implementation

The Federation Development and Execution Process (FEDEP) describes the activities involved in HLA federate and federation development and execution. One of the key elements needed by all phases of the FEDEP are the federation requirements.

Requirements support federation design and developments, identify federate roles and responsibilities, provide the basis for testing and accrediting a federation, and are used as the assessment criteria in validating the performance of a federation execution. An efficient and effective mechanism useful for capturing and tracking requirements is vital and necessary to support and encourage FEDEP activities. *Synetics* discovered during the Phase II effort, that the concept of Use Cases, borrowed from the object oriented software engineering world, provides a way for HLA simulation engineers to capture federation requirements and to track those requirements through multiple stages of the FEDEP. Specifically, Use Cases provide a blueprint used to:

1. Capture sponsor requirements and federation objectives
2. Support scenario development and conceptual analysis
3. Facilitate meta-data matching (reuse), and incremental, component-based federation development (BOMs)
4. Identify critical test points, and provide the basis for test and VV&A plans
5. Evaluate the success of a federation execution

Synetics desired and accomplished to facilitate FEDEP automation and establish a customizable, integrated tool environment. This automation and customization was another innovative contribution that *Synetics* provides to the community through CAFDE and OMSuite™. Section 2.3.2 below provides a more detailed description of the OMSuite™ tools and capabilities.

2.1.3 Use Cases

Another innovative contribution by *Synetics* was the use of Use Cases in the capturing of sponsor objectives and requirements. The following paragraphs describe the capturing of objectives and requirements and how Use Cases work best for capturing and encapsulating these requirements for traceability.

Figure 4 illustrates the Requirements Stage defined by FEDEP Steps One and Two. Inception (Step One) begins when one or more federation engineers, in conjunction with federation sponsor(s), establish the rationale for the federation and decide on the scope and subsequent requirements of the federation and individual federates. Elaboration (Step Two) follows when one or more federation engineers collect more detailed requirements, and perform high-level analysis and design to ultimately create the plan for construction. The output generated from these steps is identified as the *Blueprint* or construction plan.

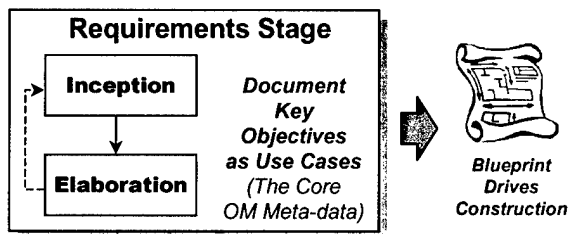


Figure 4 - Federation Requirements Effort

Like an architectural blueprint for a house or building, a Blueprint provides a reference for users, developers, and inspectors in support of the development, maintenance, testing and analysis of a federation. Similarly, solid functional requirements can be identified and used at each stage of the FEDEP by examining the intended goals and requirements of the federation. The collection of these functional requirements,

documented as Use Cases, establishes a highly useful *Blueprint*. The FEDEP *Blueprint* contains a set of requirements that will direct the construction, maintenance, and execution of a federation through FEDEP Steps Three, Four, Five, and Six (see Figure 5). The *Blueprint* also contains the high-level scenario containing the execution objectives specified by the federation sponsors. Therefore, the *Blueprint* must be in a form that facilitates traceability from Requirements to Construction. The common technique used in the object modeling community to identify such requirements and object model meta-data is through Use-Case definitions.

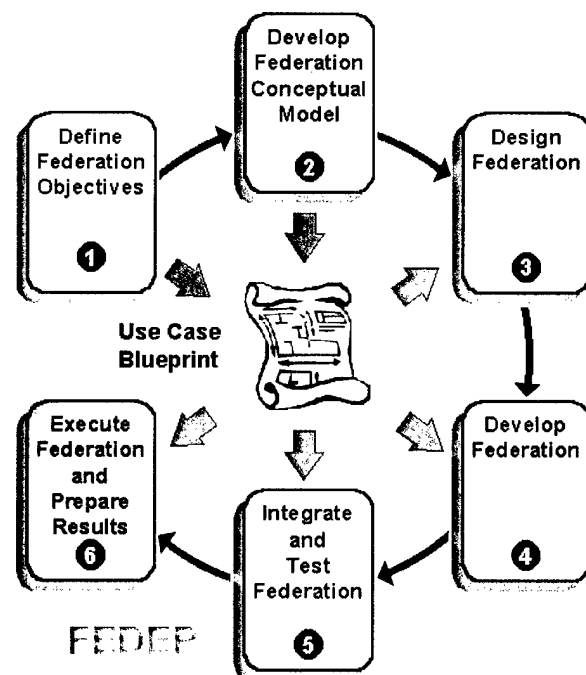


Figure 5 - Blueprint Centric FEDEP

A Use-Case identifies a functionality that one or more federates will perform in response to a stimulus. A single Use-Case captures a key requirement to be represented in the virtual battlespace environment. Thus, Use-Cases provide the vehicle for capturing requirements and object model meta-data

that can be passed to tools supporting FEDEP Steps Three, Four, Five and Six. In addition, Use-Cases provides a means of traceability and the definition of high-level test criteria. The collection of Use-Cases, grouped by sponsor objectives, provides the content of the *Blueprint*. It is important to note that while developing Use-Cases federation engineers may wish to refine the rationale and sponsor objectives. Again, CAFDE recognizes this iterative development of requirements as a normal and natural occurrence.

2.1.4 Base Object Models (BOMs)

BOMs Another innovative contribution by the *Synetics* development team was the Base Object Model (BOM) methodology. This methodology tackled the area of FOM reuse within modeling and simulation. The *Synetics* development team understood the concepts of reusability from their experience within the software engineering and knew that this concept was vital to HLA.

The BOM concept theorizes that pre-built simulation components could be either extracted from existing FOMs or built as new (for reuse), and used later to support the development and maintenance of FOMs and SOMs. The BOM concept is a highly regarded approach currently being investigated within the SISO community.

By definition, a BOM reflects a single aspect of federation interplay that is useful as a building block for FOMs and SOMs. The CAFDE Architecture and OMSuite™ were designed to support the various phases of federation development such as those described within the FEDEP, to include support for BOMs.

2.1.5 Adaptable Federates

Within HLA, interoperable systems, simulators, and real-time applications such as viewers and loggers are known as *federates*. A *federation* consists of multiple federates that have the capability of interoperating among one another; exchanging and reflecting data during a *federation execution*. Thus far, the most difficult task is adapting a system, simulator or application to be able to participate as a federate within a single federation. Since the Federation Object Model (FOM) identifies the characteristics of a federation, and each federation is represented by a FOM, federates will need to be able to rapidly transition from one FOM to another FOM with minimal impact and in minimal time. *Synetics* addressed this problem through the innovative “*Adaptable Federate*” concept.

Adaptable Federates support this anticipated transition requirement through *Object Model (OM) Mapping and Inspection*. If a federate is expected to participate in a wide variety of federation executions and the objects defined in each FOM are quite different, then the federate will undergo substantial change.

As illustrated in Figure 6 a federate represented by the Simulation Object Model (SOM) may be required to participate with federation represented by FOM X. Typically, the federate’s simulation code will be written so that it can publish and subscribe to the FOM X objects and interactions for which the federate is responsible. Suppose in the following month, it’s required that the federate participate in another federation represented by FOM Y. In order to participate, changes to simulation code are implemented which allow the federate to publish and subscribe

to the FOM Y objects and interactions for which the federate is now responsible. The second integration effort requires significant code changes, re-compiling and re-linking. Once changes are made, the federate may no longer be able to plug-and-play with federation FOM X again unless either the modification process is repeated or the previous federate was separately maintained and managed. In the latter case, multiple instances of the same federate are not at all a desirable circumstance.

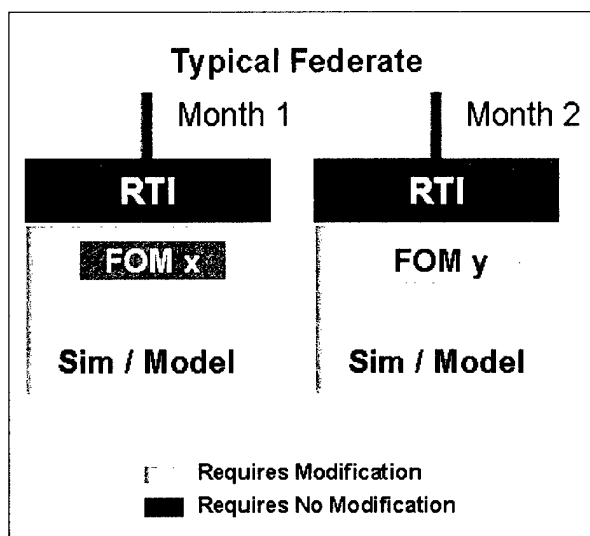


Figure 6 - Typical Federate Integration

The “Adaptable Federate” concept, however, provides a way to maintain the internal object structure of a federate that has already been coded. This mechanism is provided through an Adaptable Federate Link Module (AFLM) as illustrated in Figure 7. In this case, if a federate that is participating with the federation represented by FOM X is then expected to participate in a federation represented by FOM Y, the effort required to transition from FOM X to FOM Y requires less time. As shown in this illustration, the effort could realistically be accomplished within a day rather than months.

The key in maintaining the integrity of the federate and providing this rapid transition is for the federate to be fully represented by its SOM. Then, within the AFLM, the necessary code implementations can be identified that allow a SOM-based federate to participate in a FOM-based federation.

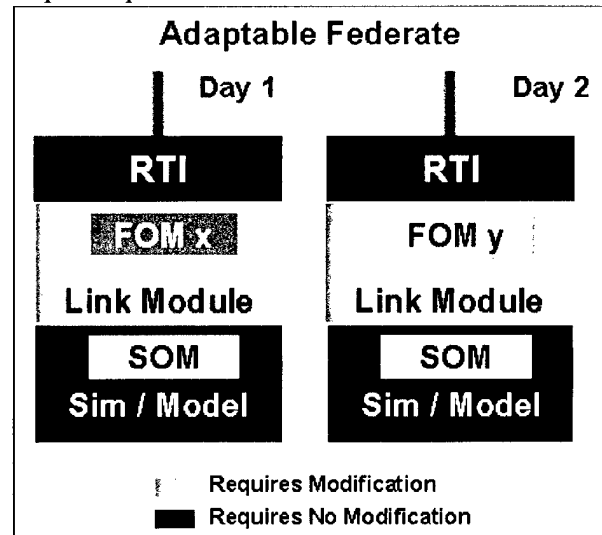


Figure 7 – Adaptable Federate Integration

It is through object model mapping and inspection, that federates can adapt to new and existing federations in the M&S community. This is accomplished by examining the role of a federate’s SOM and identifying the SOM-to-FOM mappings.

2.1.6 Federation Engineering Collaboration

The successful development of an information system whether it be a software application or an HLA federation often depends upon well-managed collaboration during the development process. The CAFDE Architecture provides an innovative approach to support cross-tool environment collaboration.

Within HLA federation development and other development arenas, data often needs

to be shared among multiple users. Common third party collaboration tools, such as a white boarding tool can be extremely useful, but often lack the direct exchange support needed for specific data types. For instance, over the past several years Use-Cases have recently been identified as a vital aspect of software engineering for capturing requirements and essential conceptual meta-data. Its use is even spreading to the HLA arena. Thus, it would be useful to be able to share Use-Cases with other engineers who are involved in the development effort. However, a third party tool may not provide the means necessary to share these Use Cases directly among multiple engineers. The CAFDE Architecture, however, provides the management mechanism for collaborating data, such as Use-Cases, XML and Data Interchange Format (DIF) based content. As a result, the application developer does not have to worry about having wrapping the data within a network packet message; the CAFDE Engine and Network Interface perform this task once the data has been delivered to the Engine by the application through one of the several CAFDE API *publish* routines.

2.2 Community Impact & Involvement

The *Synetics* SBIR development team has desired from the earliest proposal preparation days to not just develop a few tools and then move on to future work, but to have an impact upon the HLA community with our tools and personal involvement. A great deal of time was expended in the areas of research, publications, tools, conferences, and interaction with other companies in the hope of improving the use of HLA throughout our DoD sphere of influence and in commercial applications. The following paragraphs discuss *Synetics* involvement and impacts.

2.2.1 CAFDE

As was described in paragraph 2.1.1 above, *Synetics* wanted to provide the HLA federation engineering community with an open tool architecture that provides a way for users to choose the tools of their choice, regardless of the tool vendor, within an integrated environment. CAFDE provides this architecture.

2.2.2 Simulation Interoperability Workshop (SIW) Participation

Synetics OMSuite™ development team has been actively involved within the Simulation Interoperability Workshops during the two years of the SBIR effort. *Synetics* has contributed seven papers for publication and presentation in various forums on various topics associated to the efforts described previously. Furthermore, *Synetics* personnel have been active with individual forums in an effort to serve and to impact the community; we have participated in study groups and various forums as co-chairman, secretaries, and panel participants.

2.2.2.1 Publications and Presentations

One area of involvement in SIW for *Synetics* has been in the papers published and presented at the workshops. These papers are:

- *Base Object Models (BOMs): Reusable Component Objects for Federation Development* by Paul Gustavson, John Hancock (ArtisTech, Inc.) and Mark McAuliffe (STRICOM) [98F-SIW-034]
- *CAFDE: An Open Tool Architecture for Next Generation Automation Tools* by the FEDspresso team at *Synetics* and Mark McAuliffe (STRICOM) [98F-SIW-049]

- *CAFDE TDK: Facilitating Tool Interoperability and FEDEP Automation* [99S-SIW-031]
- *Object Model Use Cases: A Mechanism for Capturing Requirements and Supporting BOM Reuse* [99S-SIW-115]
- *Lessons Learned and Benefits of CAFDE Tool Integration* [99F-SIW-074]
- *Use Cases – A Blueprint Approach for Federation Development, Testing, and Analysis* [99F-SIW-112]
- *Object Mapping and Inspection: The Key to Adaptable Federates* [00S-SIW-044]

2.2.2.2 Tools Demonstrations

Synetics has presented the CAFDE and OMSuite™ products in booths for the community to see at each SIW and the last two I/ITSEC conferences, and participated in the "HLA Tools on Parade" sponsored by DMSO at the Fall 99 SIW. In addition, *Synetics* demonstrated and presented the CAFDE architecture and OMSuite tools to JMASS 2000 this past spring.

2.2.2.3 Study Groups

Synetics personnel were involved in shaping the HLA community by their involvement in various study groups. In particular was Paul Gustavson's involvement with the Reference FOM SG and currently with the BOM study group that he leads.

2.2.2.4 Forums

Paul Gustavson served as an officer of the PROC Group and Jane Bachman served as an officer for the EMF Group the past year and a half.

2.2.3 Interservice/Industry Training, Simulation and Education Conference (I/ITSEC)

Synetics continued their community involvement by providing a booth at the 1998 and 1999 Interservice/Industry Training, Simulation and Education Conferences (I/ITSEC).

During the 1998 conference, *Synetics* shared a booth with Spectra-Research and presented the CAFDE architecture and TBX to the community.

During the 1999 conference, *Synetics* presented OMSuite™ to the community and met with Marconi (now, British Aerospace) to discuss specifics on enhancing OMSpector.

2.2.4 Joint Modeling and Simulation System (JMASS)

Synetics participated in the JMASS Conference in Dayton, OH from April 24th thru the 27th, 2000. *Synetics* manned a booth at the conference to demonstrate OMSuite™ to the JMASS community. During one of the demonstrations, Jane Bachman was invited to present the CAFDE architecture and the CAFDE Toolbox concepts and products to a forum.

2.3 Resulting SBIR Products

Synetics has developed a full-scale CAFDE implementation Object Model tool suite for the DoD and commercial communities called OMSuite™. OMSuite™ allows HLA simulation environments to be rapidly planned, designed, developed, and prototyped. As Figure 8 illustrates, OMSuite™ contains tools to capture requirements, OMCase™ (FEDEP steps 1 & 2); build and modify object components,

OMBuilder™ (FEDEP steps 3 & 4); map and inspect object models, OMSpector™ (FEDEP steps 4 & 5); manage lexicons, OMLex™; and provide Inter/Intra-net

Collaboration, OMNet™. The following paragraphs describe the individual tools and their respective contributions.

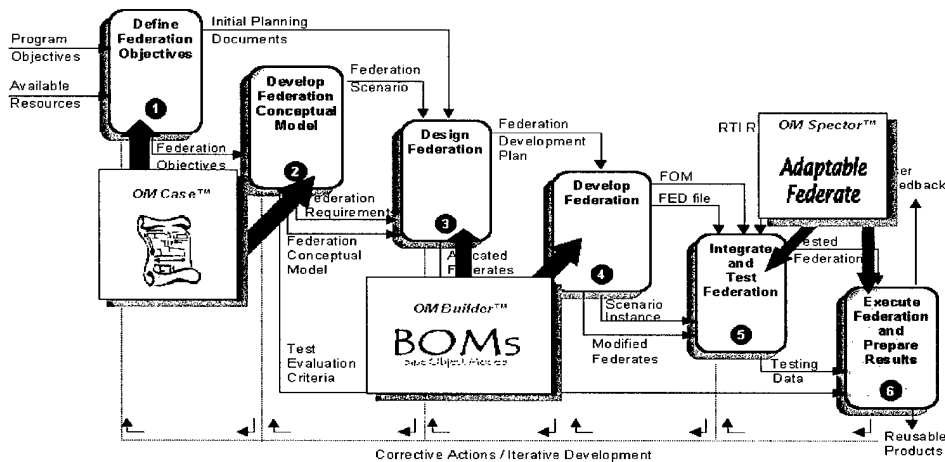


Figure 8 – OMSuite and the Six-Step FEDEP

2.3.1 CAFDE TBX



The CAFDE TBX is an implementation of the open CAFDE specification. A CAFDE website, www.cafde.org, was created to provide information and feedback with end users and tool developers on CAFDE and the *Synetics* implementation, CAFDE TBX. The CAFDE TBX, along with periodic upgrades in conjunction with SISO conferences, was made available from the CAFDE website during the Phase II efforts. The components of the CAFDE TBX are OMManager™, CAFDE Engine, OMNet™; CAFDE Specification; and the CAFDE Application Tester (CAT). The CAFDE TBX benefits the M&S community, both user and tool developer, by facilitating tool

interoperability and automation. The efforts of the CAFDE TBX are detailed in the following paragraphs.

2.3.2 OMSuite™ HLA Tool Suite



OMSuite™ initial beta was released and introduced at the SIW Fall 1999. The OMSuite™, version CR1.0, candidate release was demonstrated at the I/ITSEC '99 show. Based upon feedback from I/ITSEC '99, an OMSuite™ version CR1.1 was released. OMSuite™ version 1.0, containing some individual tool upgrades, was publicly released on 2 February 2000 and *Synetics*' first OMSuite™ sale was packaged and delivered.

2.3.2.1 OMManager™

OMManager™ is considered as the “handle” to the CAFDE toolbox serving as the visual link in establishing the IDE. This application resides at the top of the user’s desktop and as prototyped in Phase I, provides the M&S community Tool management, federation project management, desktop management, collaboration connection views, lexicon support and a “true” FEDEP automation capability. During the Phase II efforts, OMManager™ was updated with some features to further enhance the IDE. A “Desktop Monitor” feature was added which provides the user the capability of receiving notification from the CAFDE engine that a non-CAFDE Enabled tool generated a file. Another feature added is the application tabular management. Applications activated in CAFDE are managed via a tabular bar located at the bottom of OMManager™. The user receives the benefit of locating active applications on the desktop easily and quickly. OMManager™ tool integration allows not only CAFDE Enabled tools but non-CAFDE Enabled tools as well. For example, OMManager™ does not restrict the integration of a third-party tool, such as a web browser for accessing repositories.

2.3.2.2 OMCase™



OMCase™ was developed primarily to support requirement activities for object oriented software and HLA federation design. OMCase™ provides a Use Case template mechanism for capturing and tracking functional requirements in an easy-to-read, easy-to-track text format, and provides the following capabilities:

1. Capturing sponsor requirements and objectives
2. Supporting scenario development and conceptual analysis
3. Facilitating meta-data matching (reuse), and incremental, component-based design of software systems and HLA federations
4. Identifying critical test points, and provide the basis for test and VV&A plans
5. Evaluating the success of a completed system or HLA federation.

OMCase™ uses Cockburn’s Template in XML to document Use Cases. The complete collection of Use Cases forms a Blueprint. In order for the information within the Blueprint to benefit the entire development process, a mechanism for OMCase™ to share this information with other tools is also available. Other tools that are CAFDE Enabled can subscribe to blueprint information and receive that information automatically in a seamless and integrated manner. Another method is through file sharing. OMCase™ generates the blueprint in XML, which can be easily parsed and loaded by other tools and browsers. OMCase™ also can be used to generate fully automated requirements documents once Use Cases are input. In short, OMCase™ supports tool integration and trace ability of the federation requirements from definition by the sponsors through execution analysis.

2.3.2.3 OMBuilder™



OMBuilder™ offers efficient and effective mechanisms to define object and interaction classes along with their attributes and parameters, respectively, which make up Simulation Object Models

(SOMs), Federation Object Models (FOMs), and Base Object Models (BOMs). With OMBUILDER™, federation engineers have the ability to build object models, generate required documentation and DIFs, associate the object and interaction classes to form reusable component "piece parts" called BOMs, and use/reuse BOMs in the formation of FOMs and SOMs. As a CAFDE Enabled member of OMSuite, OMBUILDER™ provides for the import of sponsor objectives and requirements from OMCase in the form of Use-Cases. OMBUILDER™ also provides developmental status against the sponsor objectives, allows for the assignment of object and interaction classes as necessary, coordinates/maintains the object model's lexicon via OMLex™, and provides the object models to, OMSpector™, for federation integration, testing, and verification.

2.3.2.4 OMSpector™



OMSpector™ supports the concepts of Object Model mapping and SOM to FOM adaptability from one federation to another federation. . OMSpector™ is a tool that provides the user the ability to inspect two object models side-by-side allowing the user to view the complex data types, enumerations, class objects/attributes, and interactions / parameters in each object model. Upon inspecting the objects, OMSpector™ provides the user with the ability to identify discrepancies between the federation model and the simulator model and to link objects / attributes, interactions / parameters, complex data types and enumerations. Once a link has been made, OMSpector™ automatically identifies the discrepancies between the linked items and can generate C++ stub code called Adaptable Federate Link Module (AFLM).

This allows the user to insert conversion routines necessary to map data during real-time execution

The mapping of objects is stored via the Object Model Synchronization (OMS) DIF. The OMS DIF can be saved in Backus-Naur Format (BNF) or the eXtensible Markup Language (XML) format. The OMS DIF was developed during phase II along with the development of the application, OMSpector™.

2.3.2.5 OMLex™



OMLex™ provides for the management of lexicon data used in the design, development, and delivery of software projects and HLA federations. OMLex™ provides access to repositories and can read and produce OMDD DIFs, as well as text files. OMLex™ operates as a stand-alone application or can reside as an automated system tray component assisting in maintaining an uncluttered desktop. As with all OMSuite™ tools, OMLex™ is fully integratable with other CAFDE Enabled tool, allowing the data dictionary to be built and maintained as your objects are built. With OMLex™, your data dictionary is always there when needed.

2.4 SBIR Product Commercialization

The success of the SBIR is in the final commercialization and sale of the products and technologies developed during the research process. *Synetics* commercialization strategy during this SBIR was broken down into three main areas: 1) Develop and freely distribute products that would provide a direct benefit to the HLA community as a whole, 2) Develop products that could be shrink wrapped and sold for profit, and 3) Provide services, using the developed products, for profit. *Synetics* pursued

each of these areas in its effort to commercialize the OMSuite™ product line and services.

In an effort to genuinely support and advance the research and development of HLA tool technology, *Synetics* felt that certain aspects of our research and development should be provided free of charge to the HLA community. The CAFDE TDK with its APIs, foundational tools (such as OMManager™, and OMNet™), components (such as the CAFDE Engine), and support documentation were made available to the community in order to provide tool developers with an environment from which to easily integrate their tools with other vendors. This provides a CASE-like environment for tools, no matter who manufactured them, to be integrated and share data. *Synetics* made solid efforts to encourage the use of the CAFDE architecture within the tool developer's community with little success. IBIS Research, Spectra-Research and Pitch, AB were the receptive companies to use the CAFDE architecture and currently have tools that are CAFDE compliant and can co-exist with the OMSuite™ tools in a common integrated environment.

In the area of developing products that would be shrink wrapped and sold for profit, *Synetics* developed the OMSuite™ tool suite which, as described in paragraph 2.3.2 above, consists of OMManager™, OMNet™, OMCase™, OMBuilder™, OMSpector™, and OMLex™. These tools are being marketed to DoD and commercial organizations for HLA federation engineering. Additionally, the tool suite is used in-house, within *Synetics*, as software engineering tools. Currently, we have sold OMSuite™ to two non-DoD customers (Plexus, Inc. and CACI) and to one foreign country (Centre de Recherches pour la defense Valcatier – Quebec). We have had an additional four inquiries from U.S. and foreign interests recently that may generate sales in the near future.

Synetics decided early in the marketing phase to sell the products at a price similar to commercial integrated development environments (e.g., Borland's C++Builder and Delphi IDE's). As

the tools progress in their maturity process, especially as software engineering tools, *Synetics* envisions volume sales of the OMSuite™ tools rather than a few sales of high priced products. However, it is not in the sale of the tools that *Synetics* envisioned the greatest payoff.

The market is now blooming with several excellent HLA development tools, each providing similar as-well-as unique capabilities and features. With the quantity of tools appearing on the HLA development scene and with the high level of competition, *Synetics* realized early that the greatest payoff of this Phase II effort would be in the area of "services provided." These services would be to companies and DoD customers that are in need of the technologies and benefits that HLA provides. *Synetics* efforts in providing HLA services are described in the following paragraphs.

2.4.1 U.S. Commercial

Synetics feels that the educational and entertainment markets are two commercial sectors that would benefit from the OMSuite™ tools. OMSuite™ will allow for the rapid development of educational and entertainment gaming environments in which multiple players could participate over a network. OMSuite™ will aid in the design of interchange protocols for multiplayer environments, the management of distributed development through collaboration, and the creation and integration of new objects within game and simulation engines (resulting in graphics and interactions). During the Phase II SBIR effort, *Synetics* worked closely with Focus On The Family to seek interest in HLA-based entertainment.

Focus On The Family is a commercial, non-profit organization with their main goal being the raising, shaping, and preparing of children for a life of service to God, country, and family. As a part of their efforts, they produce a weekly radio drama, for kids of all ages, called "Adventures in Odyssey." This program is about a fictitious town called "Odyssey," a place

in the town called "Whit's End," and the people of Odyssey. *Synetics* felt that this radio series was an excellent place to prove the concept of using HLA in a multi-player, web-based gaming environment. *Synetics* felt the benefits from this commercialization effort would be: 1) royalties on the sale of the software required to play the game, 2) additional funding from Focus On The Family for the improvement, growth, and further development of the games, and, 3) the establishment of HLA in commercial educational gaming.

In an effort to be involved with Focus On The Family, *Synetics* OMSuite™ team members traveled to Colorado Springs, CO. on four different occasions to present and update Focus On The Family personnel with the HLA gaming vision. Initially, Focus On The Family personnel were excited about the prospects of our proposals. On a second visit to Colorado Springs, *Synetics* personnel took with them a gaming engine with graphics developed that would interact in an HLA environment. We believe that FOTF were impressed and finally convinced that we had a technology and ability to develop a multi-player, web-based gaming environment using HLA for them. One week after returning to Virginia, *Synetics* received a box containing a large amount of audio/visual materials to use in a proof-of-concept. This encouraged *Synetics* to write a proposal detailing the on-line HLA-based game that was submitted at their request. *Synetics* felt that this was a very positive step toward our Phase III effort of developing and HLA-based on-line game. Unfortunately, we received notification from Focus On The Family in February of 2000 that funding was not obtainable and that Focus On The Family reluctantly had to decline the proposed Phase III partnership agreements and further consideration of our proposals for the on-line game. Not totally discouraged by this setback, *Synetics* personnel have continued dialoging with Focus On The Family.

Synetics was successful in marketing OMSuite™ to commercial industry. *Synetics* sold OMSuite™ to Plexus, Inc. and CACI, Inc. *Synetics* has had many inquiries about purchases and are currently following up on these leads.

2.4.2 Department of Defense

Synetics realized early that the greatest payoff of this Phase II effort would be in the area of "services provided." These services would be to companies and DoD customers that are in need of the technologies and benefits that HLA provides. At the beginning of the Phase II SBIR effort, *Synetics* contacted several DoD potential customers about providing them HLA-based federation services. The two biggest respondents were:

1. Navy's Science and Technology Manning Initiative, co-sponsored by the Office of Naval Research and the DD-21 Program Office (PMS-500).
2. Navy's Theater Air and Missile Defense BMC4I Program

The DD-21 program is a DoD based effort for the establishment and risk mitigation of the Surface Combatant of the 21st century (i.e., the next generation of surface ships). The Navy's involvement in the BMC4I program is to integrate the "space tracks" into the Navy's battlegroup environment (i.e., communication links, combat systems, and defense systems). Federation services for projects of this type are endless and will be ongoing for years. *Synetics* saw the benefit under this effort being:

1. Long-term contracts for the support and development of federations for the DD-21 and BMC4I projects

thereby allowing *Synetics* to remain a force in HLA technologies.

2. The establishment of HLA in the DoD arena, which will bring in more DoD based customers.

For the DD-21 and BMC4I projects, the benefit was the ability to perform simulations and use the results to decrease technical risks, reduce cost, and prove/disprove advances concepts. During the Phase II SBIR effort, *Synetics* marketed ideas to these groups and gained respect within Naval Surface Warfare Center, Dahlgren Division (NSWCDD) as being technically sound on HLA concepts and as providers of HLA services. Two efforts are currently on going at *Synetics* in relationship to HLA services are in the area of migrating Distributive Interactive Simulations (DIS) to HLA.

The first effort is with the *Testing Experimentation Assessment & Modeling and Simulation* (TEAMS) facility. The TEAMS facility provides an unmatched environment for detailed testing, experimentation, and assessment of live and simulated sensor and sensor-to-shooter systems for the joint warfare community. Frequent use of modeling and simulation allows for cost effective testing, benchmarking, and evaluation of various levels of sensor and sensor-to-shooter engagements. The *Synetics* Phase II SBIR team is currently under contract to provide technology solutions for the TEAMS M&S efforts. This includes supporting TEAMS Capability Exercise (CAPEX) HLA efforts in testing and analyzing the Short-Stop Electronic Protection System (SEPS).

The SEPS is a mobile, electronic countermeasure system designed to protect personnel and high value targets from the

most predominant of indirect fire threats without operator intervention. It accomplishes this by countering artillery and mortar proximity radio frequency (RF) fuzes. It was developed by Condor Systems for the US Army PM Firefinder and is comprised of a core Receiver/Transmitter (R/T) with additional components to allow it to be configured in three distinct versions; 1) Manpack; 2) Stand-alone; and 3) Vehicular.

The second major effort that *Synetics* is currently involved with at NSWCDD is the requirements capturing, assessment of middleware products, and assessment of associated costs for transitioning the Distributive Engineering Plant from DIS to HLA. The *Synetics* team has been working on a DIS to HLA federation development plan with the DEP project. *Synetics* is proposing the use of OMSuite™ tools to capture the requirements and to produce the object and interaction models (and also to develop and use BOMs) as a part of the DEP conversion. Another company will be migrating the legacy code but we will be involved throughout the entire federation development process. This is a short-term effort that *Synetics* would like to see grow into a full HLA implementation of DIS entities at the DEP.

2.4.3 International

Synetics has been actively marketing OMSuite™ tools to both U.S. and international companies and government agencies. *Synetics* received an order from the *Centre de Recherches pour la defense Valcatier* in Quebec, Canada. We have had an additional inquiries via our OMSuite™ website from other international interests that may generate sales in the near future.

Section 3

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